On a Method of Finding the Conductivity for Heat.

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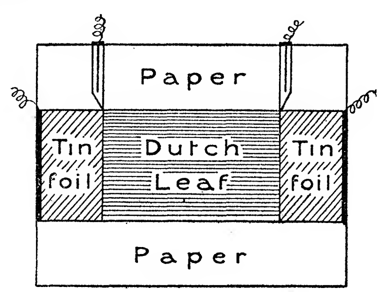
1. The method to be described for finding the conductivity for heat of a class of bad conductors may be considered to be an extension of a method given by one of us for finding the conductivity of substances mostly in the form of powder or small grains. In that paper the conductivity is inferred from the fall of temperature at different points from the axis of the mass, and the heat supplied to it by an electric current passing through a wire.

In the present paper the body was in the form of flat layers, and the heat was supplied by passing an electric current through a thin metallic layer—in our case a piece of Dutch leaf. The leaf in the form of a rectangle was gummed to a piece of thin paper, and the current passed into it by two sheets of tinfoil also gummed to the paper and to the Dutch leaf along its opposite sides, the foil overlapping the leaf by spaces of about 1–2 mm., the two pieces of foil and the Dutch leaf forming a rectangle about 18 cm. long and 8 cm. wide, of which the Dutch leaf occupied the length of about 8 cm.

The current was introduced and removed by soldering copper wires along the outer edges of the foil, which was then covered for about 1 or 2 cm. with strong tissue paper so that the whole could be handled freely.

The potentials at the ends of the leaf were obtained by cutting the foils so as to leave two tags attached to the main foils by thin shreds and connecting thin wires to them in the same way as the main current leads were attached. The whole appearance of the heating arrangements would be somewhat as in the figure.



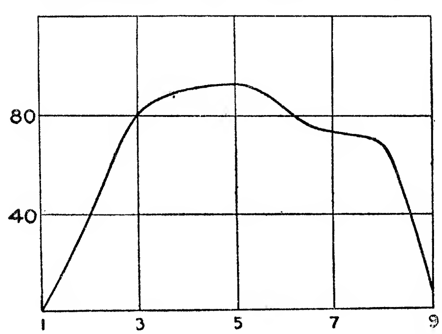
This paper, with a similar sheet laid over the thin metallic sheets, will be called the "heater."

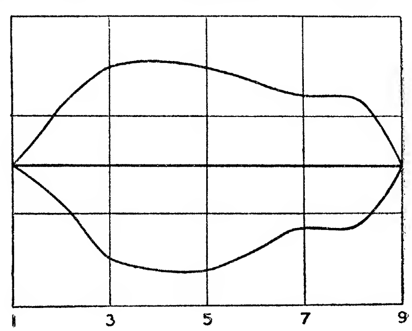
2. In our first experiments the "heater" was placed in the centre of a system made as alike above and below it as possible, the outer members

of which were two brass boxes 19·7 cm. long by 14·8 cm. wide and 3·6 cm. deep, through which tap water was allowed to flow, thus keeping the surfaces at a constant temperature, the same for both. The other parts reckoned from the heater were (1) a thermo-electric junction made from No. 39 wires of iron and eureka; (2) a slab of the material whose conductivity was to be found, usually $\frac{1}{2}$–1 cm. thick; (3) another thermal junction; (4) a sheet of blotting paper, and then the flat surface of the cooling box. On the other side of the heater the parts were exactly the same so far as we could make them, but there would probably be always some slight inequality in the thicknesses of the two slabs. This, however, is of no consequence to the final result.

3. If we could assume that the Dutch leaf is uniformly warm when the heating has been so long continued that the temperature has become everywhere steady, the mathematical problem of the flow of heat from it on both sides would be the same as that of finding the lines of force between the plates of a plane condenser. That is to say, the lines of flow would be perpendicular to the surface of the leaf and to the parallel surfaces of the coolers, and if the leaf were uniform we might, in any case, expect this to be true for an area near the centre of the leaf. Assuming such a state of things to exist, and h to be heat produced by the current in one second per unit area, we should have $h = \mathrm{K}(\partial\theta_1/a+\partial\theta_2/b)$, where a and b are the thicknesses of the two slabs, $\partial\theta_1$, $\partial\theta_2$ the difference of temperatures on opposite sides of the slabs, and K is the conductivity.

4. To satisfy ourselves on this point we arranged a number of thermal junctions at equal distances along the Dutch leaf and separated from it by a thin layer of paper, and plotted the change of temperature along the leaf. The results for two leaves are here given, one of the figures showing the



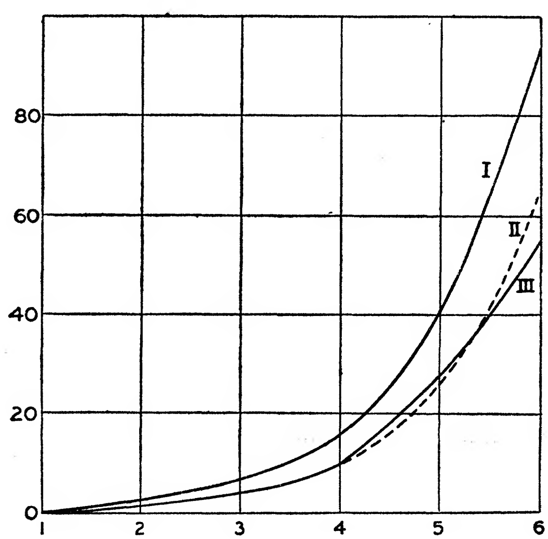


change for points above and below the leaf; in this case the curves above and below are alike, as we should expect.

A glance at the figures shows that there is no region of equal temperature

near the centre of the leaf, the reason being that the latter is by no means of uniform thickness all over. As this want of uniformity presented itself in all the thin metallic leaves which we tried, we looked for a means of overcoming the difficulty. After some trials with tin foil, we finally adopted the plan of placing above and below the heater two plates of copper of about the same area as the Dutch leaf. On testing the variation of temperature as before, we found that, with a copper plate 0·45 mm. thick, the variations from point to point were very small and irregular in sign, and that with a plate 0·55 mm. thick there was no appreciable change of temperature at all along its surface. The latter plates were accordingly used in our work; and to keep the system of the same thickness throughout, they were placed in a hole of the same size cut out of a number of sheets of paper having the same aggregate thickness as the copper plates.*

5. These copper plates (or equalisers) receive all the heat from the Dutch leaf and deliver it to the conducting slabs beyond from surfaces at a uniform temperature, except what may escape by conduction through the tin foils or along the paper margins of the heater. The loss of heat along the tin foils we have endeavoured to estimate by finding the distribution of temperature along the foils in the same way as was done over the surface of the Dutch leaf. The accompanying diagram shows this distribution, the ordinates



* Prof. Lees in his paper in the 'Phil. Trans.,' 1898, A, vol. 191, had already used a flat coil between two copper discs; and, indeed, he figures a system of plates very similar to the one we have employed, the difference between our methods being one of detail in the arrangement of the rest of our apparatus.

representing the rise of temperature from the ends to the junction of the Dutch leaf on an arbitrary scale.

I is taken without equalisers, II with equalisers of the same size as the Dutch leaf which they guard, III with equalisers extending $\frac{1}{2}$ cm. at each end over the tin foils. In the last case the gradient is less than in either of the other cases and is approximately uniform under the plates; we have therefore adopted this size for the plates. The thickness of the tin foils is 0·02 mm., their breadth 8 cm., and the temperature gradient at the edge of the equaliser is about 5·8° C. per cm.; if then we take the conductivity of tin foil to be about 1/11, the heat passing out along each foil is 0·0084 grm.-cal. per second, and for both foils would be double this amount.

6. From the heat thus found has to be deducted that produced by the passage of the current through $\frac{1}{2}$ cm. of the foils at each end. We proceed to estimate this amount and to find the proportion which it bears to the whole heat generated in the Dutch leaf.

The current in our experiments being kept at 5 ampères (this being as much as the heaters would stand without burning) the fall of potential along the Dutch leaf was found to be 0·659 volt, that down one of the foils 0·0498 volt, so that the heat produced in each foil was about 1/13 of that in the leaf.

In absolute measure these amounts were respectively

0·783 and 0·06 gramme-calories per second.

As the part of the foils under the equalisers was 1/10 of the whole, the heat directly generated under these is about 0·006 grm.-cal., which goes to neutralise the heat lost by conduction, leaving 0·0024 as the total heat lost at each end. The loss at both ends is therefore 0·0048, which is about 1/163 part or 6/1000 of that produced in the leaf. If we treat the flow of heat across the paper margins of the heater as negligible, we may take the heat generated as taken from the Dutch leaf, diminished by about 0·6 per cent.

7. As an example of the determination of K we may give the case of glass:—

Current	5 ampères
Fall of potential along leaf	0·641 volt
Heat produced in grm.-cal. per cm.^{2} of equaliser	$1·06 \times 10^{-2}$
Ditto corrected for conduction by foils	$1·054 \times 10^{-2}$
Mean thickness of two slabs	1·306 cm.
Fall of temperature in crossing upper slab	3·684° C.
,, ,, lower ,,	3·472° C.
Value of K	$19·234 \times 10^{-4}$

Thermal Conductivities.

Paper	$3 \cdot 27 \times 10^{-4}$ C.G.S.	Cork carpet.........	$2 \cdot 645 \times 10^{-4}$ C.G.S.
Plate glass	19·234 „	Linoleum............	3·513 „
Norwegian pine...	3·076 „	Leather	3·286 „
Mahogany	3·42 „	Fire clay brick ...	14·354 „
Ash	3·651 „	Polished clay tile..	17·415 „
Canary pine	3·916 „	Vulcanite............	4·210 „
Teak	3·974 „	Sulphur	6·151 „
Oak	5·011 „	Paraffin wax	6·649 „
Felt (green)	0·74 to 0·8 „		

Studies of the Processes Operative in Solutions. XX*.—*The Conversion of Ammonic Cyanate into Urea, especially as influenced by Alcohols.*

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In view of the importance of a knowledge of the precise effects produced by ordinary alcohol and its homologues on the course of chemical change, it is remarkable that so little has been done to elucidate, by systematic inquiry, the nature of their influence. Attention has been drawn, in earlier studies of this series (Nos. XI, XIII, XVIII), to the marked difference in the behaviour of the various homologues of alcohol, especially to the fact that the higher alcohols are the more active agents. Moreover, it is well known to physiologists that the higher alcohols have lethal properties which are scarcely met with in their lower and more soluble homologues.

Unfortunately, in many cases, the results obtained by previous workers do not afford satisfactory information on the subject, as the conditions have been such that the alcohol has not been the only variable but has been substituted for water, the amount of water being decreased as that of alcohol was increased; the effects produced might be due to either or both of these variations.

* I, 'Roy. Soc. Proc.,' 1906, A, vol. 78, pp. 272—295; II—V, *ibid.*, 1907, vol. 79, pp. 564—597; VI—X, *ibid.*, 1908, vol. 81, pp. 80—140; XI, *ibid.*, 1910, vol. 84, pp. 123—136; XII, 'Chem. Soc. Trans.,' 1911, vol. 99, pp. 349—371; XIV, *ibid.*, pp. 371—378; XV, *ibid.*, pp. 379—384; XIII, XVI, XVIII, XIX, 'Chem. News,' 1911, vol. 103, pp. 97, 121, 133, 145.